

EXTENSION THROUGH TIME ACROSS THAUMASIA, MARS. M. P. Golombek¹, B. J. Franklin¹, K. L. Tanaka², and J. M. Dohm², ¹Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109, ²US Geological Survey, Flagstaff, AZ 86001.

The Thaumasia region makes up the southern part of the Tharsis province on Mars and is made up of ancient Noachian basement and younger Hesperian plains that are complexly fractured by a number of different fault sets. Fault sets include a characteristic fanning set of long, narrow grabens known as Claritas Fossae that appear to radiate from a point to the north on Syria Planum, and the Thaumasia rift, a 100-km-wide structure that is up to a few km deep. In this abstract, the amount of extension across grabens in the Thaumasia region has been determined by measuring fault scarp widths across two generally east-west trending traverses. Results are incorporated with detailed geologic and tectonic mapping studies to derive extension versus age in this region.

Viking Orbiter images in this region are not high resolution (generally a couple of hundred meters per pixel) and the scarps are narrow (generally around 0.5 km), so that photoclinometry cannot be used to estimate the vertical relief or throw, which is required to calculate the extension across individual normal faults. Measurement of the width of a normal fault scarp can be used to estimate the extension given information about the scarp slope and the fault dip. This method results in extension estimates across normal fault structures on Mars that are only slightly more uncertain than estimates using photoclinometry or shadows and is detailed in Golombek et al. [1].

We measured fault scarp widths and shadows (where present) across 2 generally east-west traverses designed to sample all the structures across the region. The southern traverse is a 1700 km long arc from 37°S, 117.5°W to 42°S, 82.7°W. This traverse is broken up into 12 individual straight segments 50 km to 275 km in length. The northern traverse is composed of 4 segments (each segment is 133-233 km long) that form an arc between 35°S and 40°S latitude between longitudes 107°W and 92°W and 4 north-stepping segments (each segment is 48-289 km long) that extend from 18°S, 111°W to 31°S, 106°W. The total traverse is 1220 km long. The western portion of the northern traverse samples normal faults of the Thaumasia rift. Segments were located in areas where stratigraphic relationships and faulting history are reasonably well understood [2]. Segment breaks occur along strike, so that no structures are missed or duplicated. All normal fault scarp widths measured are small graben scarps [1].

A total of 218 scarp widths and 3 scarp shadows (which yields the throw of the fault) were measured across the southern traverse directly on the digital images. The summed width of the scarps is 115.3 km, yielding an extension of 10.1 km. The summed throw of the shadowed scarps is 0.6 km, which resulted from 0.3 km of extension. Taken together, total extension is about 10.4 km with a formal uncertainty of ± 8.3 km [1]. Extension across the southern traverse occurred from Noachian through Hesperian time during 2 major periods. Roughly 0.6 km of extension occurred before Late Noachian, 8 km of extension occurred from Late Noachian to Early Hesperian, and 1.7 km of extension occurred later in the Hesperian. For a total traverse of 1700 km, the regional strain is of order 0.6%.

A total of 307 scarp widths and 8 shadow depths were measured across the northern traverse. The summed width of all the normal faults scarps is 211 km and the summed depth of the shadows is 2.1 km; total extension is 18.5 km and 1.3 km, respectively, for a total of 19.8 km, with a formal uncertainty of ± 15.6 km. Of this total, all but 1.4 km occurred in the Middle to Late Noachian. The 1.3 km of extension is a local Late Hesperian set of faults in Syria Planum at the very northwestern end of the traverse (fault set III1 of [3]). The regional set of later Hesperian aged faults sampled in the southern traverse is not sampled along the northern traverse. Of the total extension measured across the northern traverse, about half appears across the Thaumasia rift in the late Noachian-early Hesperian. The strain across the entire traverse is about 2%, comparable to strain across the Tempe Terra region [1].

Extension across the north and south traverses is broadly comparable if the contribution of the Thaumasia rift is subtracted from the northern traverse. The rift occupies the entire western half of the northern traverse; if it is subtracted from the total, both traverses indicate about 10 km of extension, which could be considered a regional average. If the remaining 10 km of extension in the northern traverse is ascribed to the Thaumasia rift, it implies an extension that far exceeds the total depth of the structure. This is reasonable if faults step both down and up within the rift (as is common) so that the cumulative throw of the faults far exceeds the structural depth (up to a few km [4]). For comparison, if the Thaumasia rift were bounded by two 60° inward dipping normal faults, only 3.5 km of extension would be necessary to produce a 3 km deep rift.

The data on extension through time across the two traverses of Thaumasia agree with the broad scale geologic and structural mapping that indicates that radial grabens are concentrated near the center of Tharsis during the Late Noachian/Early Hesperian, whereas radial grabens formed further out from the center of Tharsis during the Late Hesperian/Early Amazonian [5]. Specifically, extension across the northern traverse, which is closer to the center of Tharsis, peaked in the Middle to Late Noachian. Extension across the southern traverse, which is further from the center of Tharsis, although still dominated by Late Noachian/Early Hesperian faulting, has a greater proportion of faulting during the Hesperian. For example, at least 15% of the extension across the southern traverse occurred during the Hesperian, whereas only 7% occurred across the northern traverse during this same time period, and it was associated with a local center.

References:

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- [5] Tanaka, Golombek & Banerdt, JGR 96, 15,617, 1991.